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NOTES ON SOME SPECIES OF COLEO-SPORIUM—II

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(WITH PLATES 22 AND 23)

COLEOSPORIUM IPOMOEAE

Coleosporium ipomoeae (Schw.) Burrill was first described in the uredinial stage by Schweinitz[1] in 1822, as *Uredo ipomoeae;* Burrill[2] in 1885 described the telial stage and placed the fungus in the genus *Coleosporium.* The aecial stage was discovered by the senior writer near Luray, Va., on *Pinus echinata* in 1914, and it was described[3] and the proof of its connection with the uredinial and telial stages was published in a brief note in 1917.[4]

Inoculations with *Coleosporium ipomoeae* have been made during 1915 to 1919 as follows:

Sixteen sets of inoculations were made with aeciospores from aecia on *Pinus echinata* collected from the following localities: Mont Alto, Pa; Luray and Petersburg, Va.; Asheville, N. C.; Etowah, Tenn.; Clearwater and Columbia, S. C.; Atlanta, Columbus, and Macon, Ga.; Auburn and Selma, Ala.; and Texarkana, Ark. Plants as follows were inoculated: 1 *Amsonia ciliata,* 2 *Aster conspicuus,* 1 *A. longifolius,* 3 *Calonyction acu-*

1 Schweinitz, L. D. Synopsis fungorum Carolinae superioris. Schr. Nat. Ges. Leipzig 1: 70. 1822.

2 Burrill, T. J. Parasitic fungi of Illinois. Bulletin Illinois State Laboratory 2: 217, 218. 1885.

3 Hedgcock, Geo. G., & Hunt, N. Rex. New species of *Peridermium.* Mycologia 9: 239, 240. 1917.

4 Hedgcock, Geo. G., & Hunt, N. Rex. The Peridermium belonging to *Coleosporium ipomoeae.* Phytopathology 7: 67. 1917.

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leatum, 6 *C. grandiflorum*, 1 *Chrysopsis mariana*, 2 *Convolvulus arvensis*, 13 *C. repens*, 11 *C. sepium*, 1 *Coreopsis verticillata*, 1 *Elephantopus carolinianus*, 2 *E. tomentosus*, 1 *E. nudatus*, 1 *Helianthus angustifolius*, 2 *H. decapetalus*, 3 *H. divaricatus*, 1 *H. radula*, 12 *Ipomoea batatas*, 2 *I. caroliniana*, 18 *I. lacunosa*, 16 *I. pandurata*, 5 *I. triloba*, 2 *Laciniaria elegans*, 3 *L. graminifolia*, 4 *Pharbitis barbigera*, 7 *P. hederacea*, 14 *P. purpurea*, 11 *Quamoclit coccinea*, 6 *Q. quamoclit*, 1 *Silphium simpsonii*, 1 *S. terebinthinaceum*, 1 *Solidago canadensis*, 1 *S. fistulosa*, 1 *S. rugosa*, 1 *S. multiradiata*, 1 *Vernonia glauca*, and 1 *Verbesina virginica*. Of these the following were infected, bearing mature uredinia in 14 to 18 days and mature telia in about 2 months: 14 *Ipomoea lacunosa*, 8 *I. pandurata*, 3 *Pharbitis barbigera*, and 4 *Quamoclit coccinea*.

Seven sets of inoculations were made from aeciospores from aecia on *Pinus palustris* collected in the following localities: Clearwater, S. C.; Brooksville, Gainesville, New Smyrna, and Ocala, Fla. Plants as follows were inoculated: 4 *Calonyction aculeatum*, 1 *Chrysopsis mariana*, 2 *Convolvulus arvensis*, 1 *C. sepium*, 3 *Ipomoea caroliniana*, 3 *I. lacunosa*, 5 *I. pandurata*, 10 *Laciniaria elegans*, 2 *L. elegantula*, 15 *L. gracilis*, 3 *L. pycnostachya*, 2 *L. tenuifolia*, 4 *L. graminifolia*, 6 *Pharbitis purpurea*, 4 *Quamoclit coccinea*, and 1 *Verbesina virginica*. The following plants were infected, bearing mature uredinia in 15 to 20 days and mature telia in about 2 months: 2 *Ipomoea lacunosa* and 5 *I. pandurata*.

Six sets of inoculations were made with aeciospores from aecia on *Pinus taeda* collected from the following localities: Atlanta and Macon, Ga.; Clearwater and Columbia, S. C.; and Petersburg, Va. Plants as follows were inoculated: 3 *Calonyction aculeatum*, 4 *C. grandiflorum*, 1 *Convolvulus arvensis*, 3 *C. repens*, 7 *C. sepium*, 1 *Coreopsis major*, 2 *Elephantopus tomentosus*, 1 *Helianthus angustifolius*, 2 *H. divaricatus*, 3 *Ipomoea batatas*, 6 *I. caroliniana*, 8 *I. lacunosa*, 3 *I. pandurata*, 5 *I. triloba*, 2 *Pharbitis barbigera*, 3 *P. hederacea*, 9 *P. purpurea*, 5 *Quamoclit coccinea*, 3 *Q. quamoclit*, 1 *Solidago fistulosa*, 1 *S. juncea*, 2 *Verbesina virginica*, and 1 *Vernonia glauca*. The following plants

were infected bearing mature uredinia in 14 to 18 days, and mature telia in about 2 months: 2 *Ipomoea caroliniana,* 1 *I. lacunosa,* 3 *I. pandurata,* 1 *I. triloba,* 1 *Pharbitis barbigera,* 2 *P. hederacea,* and 3 *Quamoclit coccinea.*

In the foregoing experiments all plants of species of *Calonyction* and *Convolvulus* failed of infection, although the majority were in prime growing condition. The plants of *Calonyction aculeatum* were grown from seed from a plant heavily infected with the rust in nature.

Coleosporium ipomoeae is known to occur in its aecial stage in nature on six species of pine. In this stage its range is from Pennsylvania to Florida and Texas. It is now reported for the first time on *Pinus caribaea* from Florida. In its uredinial and telial stages it occurs over a much wider territory, ranging from New Jersey and Kansas on the north to Florida and Texas on the south. In these stages it is found on species of *Calonyction, Convolvulus, Ipomoea, Pharbitis,* and *Thyella.* It has been successfully inoculated by the writers on *Ipomoea caroliniana, I. lacunosa, I. pandurata, Pharbitis barbigera, P. hederacea,* and *Quamoclit coccinea.*

The two most common and susceptible host species for the uredinial and telial stages of *Coleosporium ipomoeae* are *Ipomoea pandurata* and *Pharbitis barbigera,* of which the former has a much greater range. The most common and susceptible host species for the aecial stage is *Pinus echinata.*

COLEOSPORIUM RIBICOLA

Coleosporium ribicola (Cooke and Ellis) Arthur was first described in the uredinial stage by Cooke and Ellis[5] in 1878, as *Uredo ribicola.* The telial stage was described by Prof. Arthur[6] in 1907, and the fungus assigned to the genus *Coleosporium.* Dr. Long[7] discovered and described the aecial stage and proved its connection with the *Coleosporium* in 1916.

[5] Cooke, M. C., & Ellis, J. B. New Jersey Fungi. Grevillea **6**: 86. 1878.

[6] Arthur, J. C. North American Uredinales **7**: 86. 1907.

[7] Long, W. H. The aecial stage of *Coleosporium ribicola.* Mycologia **8**: 309–311. 1916.

The following inoculations have been made with *Coleosporium ribicola:*

During 1917, three sets of inoculations were made with aeciospores from aecia collected on *Pinus edulis* at Poncha by E. Bethel and the writer, and at Stonewall, and Trinidad, Colo., by E. L. Johnston and the senior writer. The following plants were inoculated: 1 *Grossularia inermis* (Rydb.) Cov. & Britt., 5 *Ribes aureum* Pursh., 1 *R. malvaceum* Sm., 2 *R. nigrum* L., and 2 *R. odoratum* Wendl. Of these plants, 2 *R. aureum* were infected with the rust, bearing uredinia in 14 to 16 days.

June 22, 1918, aeciospores from aecia collected by E. Bethel and the junior writer, June 15, on *Pinus edulis* near Del Norte, Colo., were used to inoculate the following plants: 1 *Grossularia hirtella* (Michx.) Sprach., 1 *G. inermis,* 1 *G. innominata* Jancz., 1 *G. leptantha* (A. Gray) Cov. & Britt., 2 *G. missouriensis* Nutt., 1 *G. reclinata* (L.) Mill., 3 *Ribes alpinum* L., 2 *R. americanum* Mill., 2 *R. aureum,* 4 *R. inebrians* Lindl., 4 *R. nigrum,* 10 *R. odoratum,* and 4 *R. vulgare* Lam. Of these plants, the following became infected, bearing mature uredinia in 14 to 16 days and telia by August 1: 1 *Grossularia hirtella,* 1 *G. inermis,* 1 *G. innominata,* 1 *G. leptantha,* 1 *G. missouriensis,* 1 *G. reclinata,* 4 *Ribes inebrians,* 1 *R. nigrum,* 3 *R. odoratum,* and 3 *R. vulgare.*

The following additional species have been infected by inoculation with urediniospores: 1 *Grossularia divaricata* (Dougl.) Cov. & Britt., and 1 *Ribes fasciculatum* S. & Z.

October 13, 1916, sporidia from telia collected by the senior writer on *Ribes aureum* at Denver, Colo., were used to inoculate the needles of the following species of pine: 1 *Pinus caribaea,* 7 *P. edulis* Engelm., 1 *P. bungeana* Zucc., 1 *P. girardiana* Wall., 1 *P. mayriana* Sudw., 1 *P. monophylla* Torr. & Frem., 1 *P. pinea* L., 2 *P. rigida,* 1 *P. serotina,* 3 *P. strobiformis* Sudw., 3 *P. strobus,* 3 *P. taeda,* and 6 *P. virginiana.* Of these trees, 4 *P. edulis* and 1 *P. pinea* were infected, bearing numerous pycnia December 16, 1917, and very sparse aecia February 28, 1918.

Coleosporium ribicola in its aecial stage resembles very closely in gross morphology *Coleosporium ipomoeae,* and since the two

species may have a common host in the north central United States, a comparison of the two species is now given:

Coleosporium ipomoeae

Pycnia conspicuous in single extended rows on chlorotic spots in leaves, olivaceous-black to brownish-black when old, 0.4 mm. wide by 0.7 mm.[8] long (Pl. 22, fig. 1).

Aecia in single extended rows, flattened rhomboidal, rupturing apically, 0.7 mm. high by 1.6 mm. long (Pl. 22, fig. 1).

Aeciospores 19 by 26 μ with walls 1.5 μ thick.

Peridial cells 22 by 42 μ with walls 5 μ thick.

Coleosporium ribicola

Pycnia conspicuous in single short rows on chlorotic spots in leaves, hazel to chestnut-brown when old, 0.4 mm. wide by 0.7 mm.[9] long (Pl. 22, fig. 2).

Aecia in single short rows, flattened rhomboidal, rupturing apically, 1.3 mm. high by 2 mm. long (Pl. 22, fig. 2).

Aeciospores 18 by 30 μ with walls 3.5 μ thick.

Peridial cells 23 by 26 μ with walls 4 μ thick.

Coleosporium ribicola, according to our records, has been collected as follows in the United States:

O and I on Pinus:

P. edulis: Colorado and New Mexico.

II and III on Grossularia and Ribes:

Grossularia cynosbati (L.) Mill: Minnesota and Wisconsin.

G. inermis: Colorado, New Mexico, Utah, and Wyoming.

G. leptantha: Colorado and New Mexico.

G. reclinata: Colorado, Minnesota, and Wisconsin.

G. setosa (Lindl.) Cov. & Britt: Wyoming.

Ribes americanum: Colorado and Wisconsin.

R. aureum: Colorado, New Mexico, Minnesota, South Dakota, Utah, and Wyoming.

R. coloradense:[10] Colorado, New Mexico, and Utah.

R. inebrians (includes *R. pumilum* Nutt.): Arizona, Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming.

R. mescalerium Cov: New Mexico.

R. montigenum McCl: Colorado.

R. odoratum: Colorado, Minnesota, New Mexico, and Utah.

R. sanguineum: Minnesota.

R. wolfii: Colorado and New Mexico.

[8] For *C. ipomoeae* in each case 100 measurements are given from 10 collections, 4 on *Pinus echinata,* 2 on *P. rigida,* and 2 on *P. taeda.*

[9] For *C. ribicola* in each case 10 measurements from one collection on *Pinus edulis* are given.

[10] Credit should be given to Professors E. Bethel and A. O. Garrett for many collections of this rust from the Rocky Mountain region.

Coleosporium ribicola has been successfully inoculated on *Pinus edulis, P. pinea, Grossularia divaricata, G. hirtella, G. reclinata, G. inermis, G. innominata, G. missouriensis, Ribes americanum, R. aureum, R. fasciculatum, R. inebrians, R. nigrum, R. odoratum,* and *R. vulgare.*

The specimens of *Coleosporium ribicola* from Minnesota and Wisconsin were collected in 1917 to 1919. The rust, although sparse, was widely disseminated in Wisconsin in 1918. No aecial host for the rust in these two states has been found, nor is the reason known for its sudden appearance in 1917, and apparent disappearance since 1919.

COLEOSPORIUM SOLIDAGINIS

Coleosporium solidaginis (Schw.) Thüm. was first described in the uredinial stage by Schweinitz[11] in 1822. The telial stage was described by von Thümen[12] in 1878 and the fungus assigned to the genus *Coleosporium.* The aecial stage was described by Underwood and Earle[13] in 1896 and called *Peridermium acicolum.* Proof that this *Peridermium* is the aecial stage of *Coleosporium solidaginis* was published by Dr. Clinton[14] in 1907.

In 1906,[15] Arthur and Kern described *Peridermium montanum* as a new species on *Pinus contorta* from the northwestern United States and Canada. The senior writer in 1914[16] infected *Aster* with this species, and Weir and Hubert in 1915[17] infected species of *Aster* and *Solidago* with it, and this species was assigned to *Coleosporium solidaginis.*[16]

11 Schweinitz, L. D. Synopsis fungorum Carolinae superioris. Schr. Nat. Ges. Leipzig **1**: 70. 1822.

12 von Thümen, F. New Species of American Uredineae. Bul. Torrey Club **6**: 216. 1878.

13 Underwood, L. M., & Earle, F. S. Notes on the Pine Inhabiting Species of Peridermium. Bul. Torrey Club **23**: 400. 1896.

14 Clinton, G. P. *Peridermium acicolum* the aecial stage of *Coleosporium solidaginis.* Science, N. S. **25**: 289. 1907.

15 Arthur, J. C., & Kern, F. D. North American Species of Peridermium. Bul. Torrey Club **33**: 413. 1906.

16 Hedgcock, G. G. Identity of *Peridermium montanum* with *Peridermium acicolum.* Phytopathology **7**: 64, 67. 1916.

17 Weir, J. R., & Hubert, E. E. Inoculation Experiments with *Peridermium montanum.* Phytopathology **6**: 68, 70. 1916.

Inoculations as follows have been made with the aeciospores of *Coleosporium solidaginis* from 1913 to 1921:

Fourteen sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus echinata* from Mont Alto, Pa.; Petersburg, Va.; Biltmore, Black Mountain, and Marion, N. C.; Etowah, Tenn.; Columbia, Greenville, and Florence, S. C.; Gainesville and Macon, Ga.; Opelika, Ala.; and Meridian, Miss. Plants as follows were inoculated: 2 *Aster cordifolius*, 2 *A. conspicuus*, 2 *A. geyeri*, 2 *A. laevis*, 8 *A. macrophyllus*, 6 *A. paniculatus*, 1 *A. undulatus*, 5 *Chrysopsis mariana*, 6 *Elephantopus tomentosus*, 1 *Helianthus occidentalis*, 2 *Ipomoea fistulosa*, 1 *I. pandurata*, 1 *Laciniaria acidota*, 3 *Parthenium integrifolium*, 4 *Pharbitis purpurea*, 5 *Solidago bicolor*, 1 *S. chapmanii*, 5 *S. fistulosa*, 1 *S. hispida*, 2 *S. juncea*, 16 *S. multiradiata*, 2 *S. riddellii*, 5 *S. rugosa*, 4 *S. serotina*, 1 *S. speciosa*, 1 *S. squarrosa*, 4 *Vernonia flaccidifolia*, 5 *V. glauca*, 2 *V. noveboracensis*, and 4 *Verbesina virginica*. Of these plants, only those of *Solidago* were infected as follows: 1 *Solidago bicolor*, 1 *S. fistulosa*, 2 *S. juncea*, 16 *S. multiradiata*, 3 *S. rugosa*, 3 *S. serotina*, 1 *S. speciosa*, and 1 *S. squarrosa*. Mature uredinia were formed in 14 to 20 days, and mature telia in 2 to 3 months.

Seventeen sets of inoculations were made with aeciospores collected on the needles of *Pinus rigida* from Pleasantville, N. J.; Cold Spring Harbor, N. Y.; Caledonia, Greenwood Furnace, and Mont Alto, Pa.; Sugar Grove, O.; Harpers Ferry, W. Va.; Bluemont and Roanoke, Va.; Takoma Park and Washington, D. C.; and Black Mountain, Hot Springs, and Fayetteville, N. C. Plants as follows were inoculated: 2 *Aster acuminatus*, 10 *A. conspicuus*, 10 *A. cordifolius*, 3 *A. divaricatus*, 2 *A. dumosus*, 5 *A. ericoides*, 9 *A. geyeri*, 1 *A. hesperius*, 1 *A. laevigatus*, 2 *A. lentus*, 2 *A. lowrieanus*, 4 *A. macrophyllus*, 4 *A. paniculatus*, 2 *A. patens*, 1 *A. puniceus*, 1 *A. salicifolius*, 1 *A. undulatus*, 1 *A. vimineus*, 1 *Coreopsis tinctoria*, 1 *C. verticillata*, 4 *Elephantopus carolinianus*, 8 *E. tomentosus*, 1 *Helianthus occidentalis*, 3 *Parthenium integrifolium*, 1 *Senecio aureus*, 1 *S. obovatus*, 6 *Solidago bicolor*, 1 *S. caesia*, 27 *S. canadensis*, 1 *S. chapmanii*, 1 *S. erecta*, 4 *S. fistulosa*, 18 *S. juncea*, 19 *S. multiradiata*, 1 *S.*

neglecta, 4 *S. nemoralis*, 6 *S. riddellii*, 1 *S. rigida*, 7 *S. rugosa*, 3 *S. sempervirens*, 4 *S. serotina*, 3 *S. speciosa*, 11 *S. squarrosa*, 1 *S. tortifolia*, 1 *Vernonia blodgettii*, 7 *V. flaccidifolia*, 2 *V. glauca*, and 6 *V. noveboracensis*. Of these plants, only those of *Solidago* were infected as follows: 2 *S. bicolor*, 18 *S. canadensis*, 1 *S. fistulosa*, 7 *S. juncea*, 17 *S. multiradiata*, 1 *S. neglecta*, 2 *S. riddellii*, 4 *S. rugosa*, 3 *S. serotina*, and 8 *S. squarrosa*. Mature uredinia were formed in 15 to 17 days, and mature telia in about 2 months.

Ten sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus taeda* from Petersburg, Va.; Fayetteville and Lumberton, N. C.; Andrews, Clearwater, Columbia, Henry, and Sumter, S. C.; Macon, Ga., and Selma, Ala. Plants as follows were inoculated: 2 *Aster conspicuus*, 1 *A. chapmanii*, 2 *A. cordifolius*, 1 *A. dumosus*, 2 *A. geyeri*, 1 *A. laevis*, 3 *A. macrophyllus*, 3 *A. paniculatus*, 1 *A. novi-belgii*, 2 *A. undulatus*, 1 *A. vimineus*, 2 *Chrysopsis mariana*, 2 *Coreopsis major*, 5 *Elephantopus carolinianus*, 7 *E. tomentosus*, 1 *Helianthus angustifolius*, 2 *H. annuus*, 3 *H. divaricatus*, 1 *H. tuberosus*, 3 *Parthenium integrifolium*, 5 *Pharbitis purpurea*, 1 *Solidago bicolor*, 3 *S. canadensis*, 2 *S. chapmanii*, 4 *S. fistulosa*, 8 *S. juncea*, 8 *S. multiradiata*, 2 *S. riddellii*, 3 *S. rugosa*, 3 *S. serotina*, 2 *S. speciosa*, 3 *Vernonia angustifolia*, 5 *V. glauca*, and 6 *Verbesina virginica*. Of these plants, only those of *Solidago* were infected as follows: 3 *S. canadensis*, 7 *S. juncea*, 7 *S. multiradiata*, 2 *S. rugosa*, 2 *S. serotina*, and 2 *S. speciosa*. Mature uredinia were formed in 15 to 17 days and mature telia in about 2 months.

Six sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus pungens* from Sandy Hook, Md.; Bellville, Greenwood Furnace, and Mont Alto, Pa. Plants as follows were inoculated: 3 *Aster cordifolius*, 1 *A. geyeri*, 2 *A. lentus*, 1 *A. paniculatus*, 2 *A. undulatus*, 1 *Coreopsis verticillata*, 1 *Chrysopsis mariana*, 1 *Elephantopus tomentosus*, 2 *Helianthus occidentalis*, 7 *Solidago bicolor*, 3 *S. caesia*, 2 *S. canadensis*, 6 *S. multiradiata*, 1 *S. nemoralis*, 1 *S. riddellii*, 1 *S. speciosa*, 1 *S. squarrosa*, 2 *Vernonia glauca*, 3 *V. flaccidifolia*, and 2 *V. noveboracensis*. Of these plants, only those of species of *Solidago*

were infected as follows: 3 *S. bicolor*, 2 *S. canadensis*, 3 *S. multiradiata*, 1 *S. riddellii*, and 1 *S. squarrosa*. Uredinia and telia were produced in the usual time.

Four sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus resinosa* from Itasca Park, Minn. (collected by Mr. R. G. Pierce); Sharon, Vt. (collected by Dr. P. Spaulding); and Caledonia, Pa. Plants as follows were inoculated: 1 *Aster conspicuus*, 1 *A. cordifolius*, 1 *A. macrophyllus*, 1 *A. undulatus*, 3 *Campanula rapunculoides*, 1 *Convolvulus sepium*, 1 *Coreopsis verticillata*, 1 *Helianthus decapetalus*, 1 *Senecio aureus*, 1 *S. obovatus*, 2 *Solidago canadensis*, 6 *S. multiradiata*, 3 *S. riddellii*, and 1 *S. squarrosa*. Of these plants, only those of species of *Solidago* as follows were infected: 2 *S. canadensis*, 5 *S. multiradiata*, 1 *S. riddelli*, and 1 *S. squarrosa*. Uredinia and telia were produced in the usual time.

Two sets of inoculations were made February 26 and March 15, 1921, with aeciospores from aecia on *Pinus radiata* infected artificially October 7, 1920, with sporidia from teliospores from *Solidago bicolor*. The following plants were inoculated: 3 *Aster laevis*, 6 *Chrysopsis mariana*, 2 *Solidago bicolor*, 1 *S. monticola*, and 6 *S. multiradiata*. Only the plants of *Solidago bicolor* and *S. multiradiata* were infected, bearing mature uredinia in about 20 days, and mature telia in about 3 months. These inoculations were made at lower temperatures than those with aeciospores from species of pine, which were made chiefly in May and June. This explains the longer time required for the production of mature uredinia and telia.

One set of inoculations was made July 7, 1914,[18] with aeciospores from aecia collected by H. E. West of the Forest Service, on *Pinus contorta*, near Bozeman, Mont., June 25. The following plants were inoculated: 2 *Aster conspicuus*, 1 *A. cordifolius*, 2 *A. geyeri*, 2 *Coreopsis verticillata*, 2 *Elephantopus tomentosus*, 2 *Helianthus divaricatus*, 2 *Solidago canadensis*, 2 *S. juncea*, 2 *S. multiradiata*, and 2 *Vernonia glauca*. Of these plants, only those of *Aster conspicuus* and *A. cordifolius* were infected.

During 1914 to 1920, fifteen sets of inoculations were made, using urediniospores grown in pedigreed cultures from aecio-

[18] Hedgcock, G. G. L. c.

spore inoculations and taken from infected plants of *Solidago bicolor, S. canadensis, S. chapmanii, S. juncea, S. multiradiata, S. rugosa, S. sempervirens,* and *S. speciosa.* The following plants were inoculated: 3 *Aster conspicuus,* 2 *A. cordifolius,* 3 *A. geyeri,* 2 *A. laevis,* 5 *A. macrophyllus,* 1 *A. paniculatus,* 2 *A. pringlei,* 1 *A. undulatus,* 1 *Callistephus chinensis,* 6 *Chrysopsis mariana,* 2 *Euthamia graminifolia,* 3 *Elephantopus tomentosus,* 5 *Solidago bicolor,* 4 *S. canadensis,* 1 *S. chapmanii,* 1 *S. erecta,* 1 *S. fistulosa,* 1 *S. hispida,* 10 *S. juncea,* 23 *S. multiradiata,* 1 *S. neglecta,* 8 *S. riddellii,* 8 *S. rugosa,* 4 *S. serotina,* 3 *S. speciosa,* 7 *S. squarrosa,* 1 *Vernonia glauca,* and 2 *V. noveboracensis.* Of these plants, the following were infected, all bearing uredinia and some telia: 4 *Solidago canadensis,* 1 *S. hispida,* 7 *S. juncea,* 18 *S. multiradiata,* 2 *S. riddellii,* 3 *S. serotina,* and 2 *S. speciosa.* No plants of species of *Aster* were infected.

During 1915 to 1918, three sets of inoculations were made with urediniospores collected on *Aster paniculatus* near Harpers Ferry, W. Va., and on *A. longifolius* near Takoma Park, D. C. The following plants were inoculated: 1 *Aster divaricatus,* 1 *A. geyeri,* 4 *A. laevis,* 1 *A. longifolius,* 4 *A. macrophyllus,* 1 *A. vimineus,* 2 *Solidago juncea,* 1 *S. rugosa,* and 1 *S. serotina.* Only species of *Aster* became infected as follows: 2 *A. laevis* and 2 *A. macrophyllus.*

Two sets of inoculations were made on pine trees with sporidia from the telia of *Coleosporium solidaginis.* The first was made September 13, 1916, from telia collected by the writer on *Solidago rugosa* (no infected plants of *Aster* present) near Takoma Park, D. C., September 10. The following trees were inoculated: 2 *Pinus caribaea,* 3 *P. contorta,* 1 *P. coulteri,* 2 *P. echinata,* 1 *P. edulis,* 2 *P. mayriana,* 1 *P. montana,* 1 *P. palustris,* 1 *P. pungens,* 2 *P. rigida,* 2 *P. scopulorum,* 2 *P. serotina,* and 2 *P. taeda.* Of these trees the following were infected, bearing pycnia on or about December 21, 1916, and aecia about March 23, 1917: 1 *P. echinata,* 2 *P. rigida,* 2 *P. scopulorum,* and 1 *P. taeda.* The second set of inoculations was made in part from telia collected by the writer on *Solidago canadensis* near Chain Bridge, Va., September 28, 1920, and in part from telia col-

lected on *Solidago bicolor*, near Takoma Park, D. C., October 7 (no infected Asters present in either locality). Each collection was used in inoculations the day after collection. The following pines were inoculated: 2 *Pinus caribaea*, 3 *P. contorta*, 4 *P. coulteri*, 1 *P. edulis*, 1 *P. palustris*, 4 *P. radiata*, and 7 *P. rigida*. Of these, the following were infected, bearing pycnia on or about December 24, 1920, and aecia about March 15, 1921: 2 *P. caribaea*, 2 *P. coulteri*, 2 *P. radiata*, and 2 *P. rigida*.

No cultures could be made with pedigreed urediniospores from plants of species of *Aster* as none were infected in our inoculations with aeciospores. Urediniospores from infections on species of *Aster* in nature are apt to be mixed with those from infected species of *Solidago* which are nearly always present. In fact, the writer has usually found species of *Solidago* commonly infected in nature, and those of *Aster* rarely. Most of the species of *Aster* used in the inoculations were used because they were found infected in nature, and because of their known susceptibility.

The results from the inoculations are somewhat surprising. 132 plants of species of *Aster* and 241 of species of *Solidago* were inoculated with aeciospores from six species of pine from the eastern United States, viz., *Pinus echinata*, *P. nigra*, *P. pungens*, *P. resinosa*, *P. rigida*, and *P. taeda*. Of these, 142 plants of *Solidago* (59 per cent.) were infected and none of *Aster*. From inoculations with pedigreed urediniospores grown in the greenhouse on plants of species of *Solidago*, 19 plants of *Solidago* (25 per cent.) out of 77 inoculated were infected, but none of 19 plants of *Aster* inoculated were infected. These results may be interpreted in more than one way. It might be assumed that all the plants of *Aster* used were either from resistant species, or were not in proper condition for infection, neither of which is borne out by the facts, since many susceptible species were selected both of *Aster* and *Solidago*, and more than half of the plants were in splendid growing condition when inoculated. A more plausible explanation is that in the eastern United States we either have two races of *Coleosporium solidaginis*, the one on species of *Solidago*, the other on species of

Aster, or we have a second species of *Coleosporium* attacking species of *Aster*. The problem requires a further investigation before a definite solution is obtained.

Again, it must be noted that in the one experiment with aeciospores from aecia on *Pinus contorta* collected in Montana, 5 plants of *Aster* were inoculated, of which 3 were infected, and 6 plants of *Solidago*, all from the most susceptible species, were inoculated without infection. This indicates that this collection of aecia belonged to an *Aster* rust. The writer has collected the aecia of this rust on *Pinus contorta* in two regions in the west, one near Bozeman, Montana, the other in Estes Park, Colorado. The aecia in both cases were beyond maturity and immediately adjacent to the infected pine trees were infected plants of species of *Aster* which bore the uredinia of the *Coleosporium*. No infected plants of *Solidago* were found in either locality. In our inoculation experiments just given, 6 trees of *Pinus contorta* failed of infection when inoculated with the sporidia from the telia of the eastern form of the rust, although trees of *Pinus rigida* and *P. scopulorum* were abundantly infected from the same exposure under the same conditions. These results indicate that the western *Aster* rust may be distinct from the western *Solidago* rust which is probably identical with the eastern *Solidago* rust.

The aecia of *Coleosporium solidaginis* like those of *Coleosporium carneum* vary greatly in size, depending on the size of the needles of the species of pine infected. Those of *C. solidaginis* on pines with small needles, such are *Pinus echinata* and *P. pungens* (Pl. 23, fig. 1), are smaller than those on *P. rigida, P. scopulorum,* and *P. taeda* (Pl. 23, fig. 2). The pycnia and aecia of *Coleosporium solidaginis* are aggregated or clustered. Those of *C. carneum* (Pl. 23, fig. 3) on a given host are larger than those of *C. solidaginis* (Pl. 23, fig. 2), and are borne in more or less extended rows. The pycnia of *C. solidaginis* in color are grenadine-red to mahogany-red, those of *C. carneum,* orange-rufous to auburn or chestnut.

Coleosporium solidaginis has been reported as occurring naturally in its aecial stage upon 14 species of pine, chiefly in the

eastern United States.[19] It has been reported in the western United States only on *Pinus contorta* from Montana and Colorado.

Coleosporium solidaginis, in its form on *Solidago,* has been found occurring naturally in its uredinial and telial forms upon about sixty species of *Solidago,* in all regions of the United States, except in some of the southwestern states. It is now reported for the first time on the following species: *Solidago amplexicaulis, S. austrina, S. bootii, S. brachyphylla, S. celtidifolia, S. chandonnetii* Steele, *S. chapmanii, S. concinna, S. curtissii, S. decumbens, S. drummondii, S. erecta, S. fistulosa, S. glomerata, S. hispida, S. lancifolia, S. odora, S. petiolaris, S. pinensis* (Porter) Small, *S. pinetorum, S. pulverentula, S. purshii, S. rigida, S. rigidiuscula, S. speciosa, S. stricta, S. tortifolia, S. unigulata,* and *S. vaseyii.* The form occurring on species of *Aster* is known to occur on at least sixty species. In the eastern United States, it is now reported for the first time on the following species: *Aster acuminatus, A. concinnus, A. corrigiatus, A. hirsuticaulis, A. junceus, A. lowrieanus, A. oblongifolius, A. patulus, A. pringlei, A. schistosus* Steele, *A. spectabilis, A. tenuicaulis.* In the western United States it is now reported for the first time on *Aster fremontii, A. frondosus,* and *A. viscosum.* The form on the *Aster* has a range similar to that on *Solidago.*

Coleosporium solidaginis of the *Solidago* form in the eastern United States has been successfully inoculated by the writers from its telial stage on *Pinus caribaea* (*P. heterophylla*), *P. coulteri, P. echinata, P. nigra austriaca, P. radiata, P. rigida, P. scopulorum,* and *P. taeda,* and in its aecial stage upon *Solidago bicolor, S. canadensis, S. chapmanii, S. fistulosa, S. hispida, S. juncea, S. monticola, S. multiradiata, S. neglecta, S. pulverula, S. riddellii, S. rugosa, S. rupestris, S. serotina, S. speciosa,* and *S. squarrosa.*

The results of our inoculations indicate that in the eastern United States *Coleosporium solidaginis* is a rust attacking species of *Solidago* but not those of *Aster.* The *Coleosporium* on spe-

[19] Rhoads, A. S., Hedgcock, G. G., Bethel, E., & Hartley, C. Host Relationships of the North American Rusts, other than Gymnosporangiums which attack Conifers. Phytopathology **8**: 324. 1918.

cies of *Aster* is apparently distinct from *Coleosporium solidaginis*. *Peridermium montanum* Arthur & Kern apparently belongs to a rust on *Aster* and if so is distinct from *Peridermium acicolum* Underw. & Earle, the aecial form of *Coleosporium solidaginis*.

INVESTIGATIONS IN FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

EXPLANATION OF PLATES

PLATE 22

Fig. 1. The pycnia and aecia of *Coleosporium ribicola* on the needles of *Pinus edulis* (× 2).

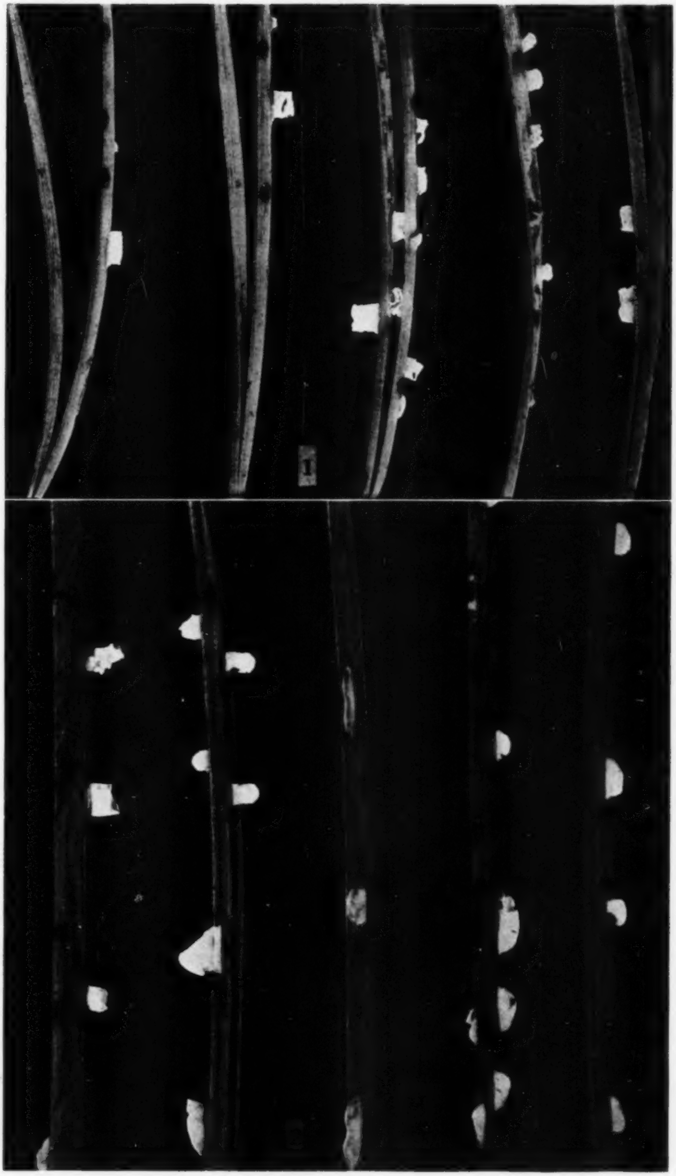
Fig. 2. The pycnia and aecia of *Coleosporium ipomoeae* on the needles of *Pinus palustris* (× 2).

PLATE 23

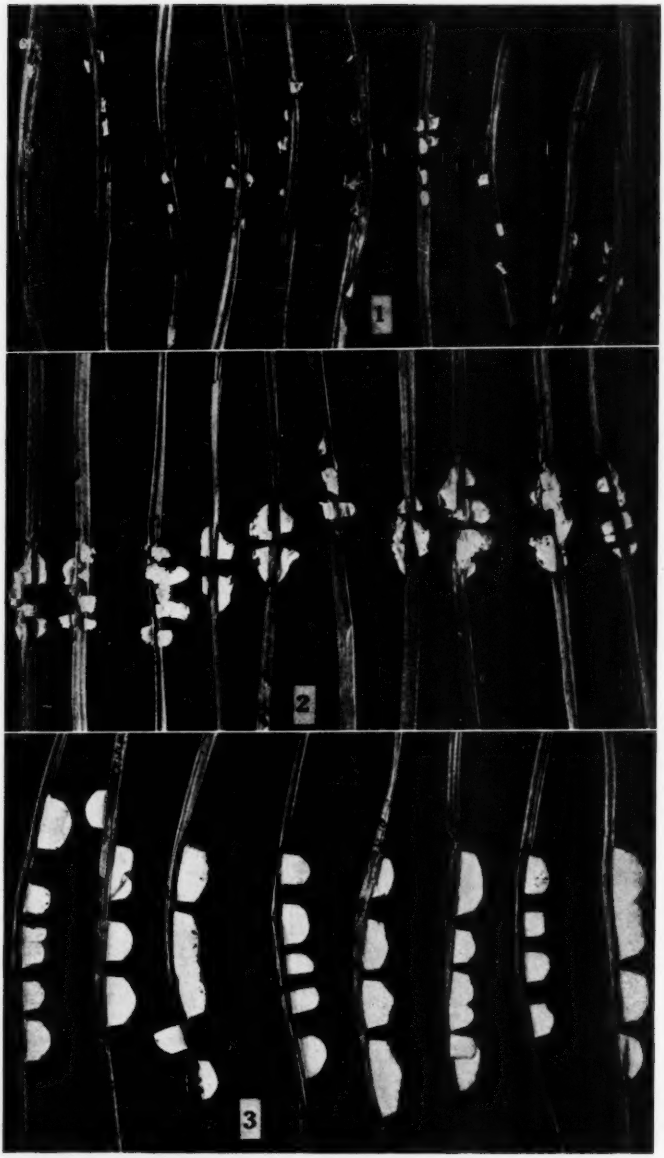
Fig. 1. Aecia of *Coleosporium solidaginis* on the needles of *Pinus pungens* (× 2).

Fig. 2. Aecia of *Coleosporium solidaginis* on the needles of *Pinus taeda* (× 2).

Fig. 3. Aecia of *Coleosporium carneum* on the needles of *Pinus taeda* (× 2).



Species of Coleosporium



Species of Coleosporium

A SKETCH OF THE HISTORY OF MYCOLOGICAL ILLUSTRATION (HIGHER FUNGI)[1]

Louis C. C. Krieger

(With Plates 24–31)

Every taxonomist will admit that illustrations are essential for the identification of many plants, and especially in the case of the fleshy, perishable fungi. To be really serviceable, however, a picture must be truthful. This seems self-evident, yet, if we make a survey of the available mycological illustrations from the earliest times to the present, we find that this quality of truthfulness was slow to develop. One of the causes of this is to be found in the freedom of the illustrator in following his imagination and another in the technical difficulties.

Like children, the old herbalists felt free to add fanciful embellishments to their pictures of plants. Porta's cuts are a good example. But the palm for nature-faking illustrating belongs to one Dr. Seger, who published (1671) under the name, *Anthropomorphus,* a cut of a "geaster," the open exoperidium of which discloses some miniature men and women, all apparently glad to glimpse the world after their imprisonment within the tissues of the plant (Pl. 24). In order to outdo the advocates of priority in nomenclature, our friend C. G. Lloyd of Cincinnati (1906*b*), has proposed (jocularly, of course, and under the *nom de plume,* "McGinty") to adopt Seger's name, *Anthropomorphus,* for the much later *Geaster* of Micheli (1729). (In parenthesis I may say that a super-conscientious systematist, in Europe, is said to have complained of his inability to find the name of this authority, "McGinty," in the literature of botany.) Another figure of Seger's, a *Xylaria*-like plant, would make a good illustration in a gynecological book.

[1] An illustrated paper read before the Botanical Society of Washington (D. C.), December 6, 1921.

Technical difficulties were no less obstructive. The only means at the disposal of the early herbalists was wood-engraving, and that art had only just reached the stage where a black line instead of a white one was produced in printing. Colored reproductions were entirely out of the question, as only some crude Italian prints from wood-blocks—initial letters, and the like—were known. There were no scientific artists in those days. The authors employed ordinary artists; and artists, as you may have learned from contact with them, are constitutionally opposed to being held down by plain, unadorned facts. Even Leonardo da Vinci, certainly a scientific man, as well as one of the greatest artists, could not resist giving an ornamental twist to his drawings of plants, drawings which, doubtless, were done for their botanic interest alone.

Let us outline chronologically the development of the principal technical means as employed by the mycologists in illustrating their works, from Clusius (1601) to Boudier (1905*b*).

The first period, that in which wood-engraving was the chief means of illustrating, embraces the fifteenth and sixteenth centuries. The wood-engraving practised by the artists of the herbalists was, as already indicated, a crude, black-line engraving. An outline-drawing was transferred to the smooth wood-block. With sharp instruments the surface was cut away everywhere except under the lines of the drawing. When completed, the block was held for printing as if it were type. In a more complex, shade-rendering form, in which white- and black-line engraving are intermingled, this ancient and most serviceable art persisted until displaced by the modern half-tone, some time in the early nineties of the last century.

The second period, in which steel- and copper-engraving played the principal rôle in mycological book-illustration, began late in the seventeenth century and lasted until well into the nineteenth.[2] In method of procedure it resembled the white-line engraving of the wood-engravers. The highly polished metal plate was cut into with suitable instruments to raise what is technically known

[2] As a means of artistic expression, it was used as early as the fifteenth century.

as a burr. This burr retained the ink for printing after the surface of the plate had been wiped clean. It is of interest that, as early as the year 1514, we find the great engraver, Albrecht Dürer, seeking a means of lightening the labors of engravers on metal. He had noticed that the armorers of his time produced the depressed, ornamental lines on cuirasses by employing acid mordants. It occurred to this wonderful man that the lines of a drawing might, similarly, be bitten into the metal, and a print made from ink left in the depressions. Dürer thus became the inventor of the art of pictorial etching, the process which, centuries later, made possible the half-tone and the tri-color print. His celebrated etching on iron, entitled "The Cannon," is here produced (Pl. 25).

Unless colored by hand—as was the practice from Paulet (1793*b*) to the time of the invention of lithography by the Bavarian actor, Alois Senefelder, between 1820 and 1830—engravings were issued without colors. But, contemporaneously with Paulet, Bulliard (1780) contrived a process by which the colors were printed on the engravings. Just how this was done, I cannot say. Very likely it was a revival of the early Italian wood-block color-printing.[3] Color-printing, as we commonly know it, before the advent of the tri-color process, was not introduced until Senefelder invented lithography.

The third period, the lithographic period, began at first with black-and-white printing, the color being added by hand as had previously been done with engravings. Fitch's figures, in Berkeley's "Outlines" (1860) and in Sarah Price's "Illustrations" (1864), are fine examples of hand-colored lithography; while the Scotchman, Greville, has left us a splendid set of hand-colored copper-engravings in his "Scottish Cryptogamic Flora" (1823).

It was not long before lithographers printed in colors. This accomplished, the way was clear for a satisfactory, as well as a more rapid, printing of fungus-pictures in their natural colors, the degree of excellence depending upon the artist who made the original paintings, and upon the lithographer who transferred the

[3] Weinmann had used a similar process in his "Phytanthoza iconographia" (1737*b*), the first work in which color was printed on engraved plates by "a new method." See Burch, Colour Printing (1910*b*), p. 66.

pictures to the stone. When tri-color printing came, these two possible sources of error were reduced to one, namely to the artist's original painting. Yet, it must be stated, though we gained in the objective rendering of a colored original through the use of the tri-color process, we also lost very materially, and this for two reasons.

First, tri-color printing, in order to counteract a certain dulling of colors[4] inherent in the process, sometimes employs highly fugitive coal-tar dyes. Secondly, in order to obtain the best results in printing, the surface of the paper must be extremely white and smooth, qualities that are secured by applying a coat of chalk. When one considers these two serious handicaps, it becomes a question whether this otherwise commendable process should be employed in reproductions that are to adorn works of high scientific value. We use and enjoy today the illustrated books of our predecessors who printed with comparatively safe colors on most enduring paper: our successors, centuries hence, will, I fear, have no such permanent, pictorial records of the work done by ourselves.

The other processes commonly used today in the reproduction of drawings and photographs, the zinc and copper line-engraving, the half-tone, and the heliogravure, need not detain us as all are familiar with the results. Of the two processes, however, the half-tone and the heliogravure, the former is much the less durable, for the reason that, as in the tri-color process, chalk-coated paper is usually the surface for the print. The mesh, present in all half-tone reproductions, may also be urged as an objectionable feature when a hand-lens examination for morphological details becomes desirable (Pl. 26). As examples of most satisfactory reproductions of photographs of fungi, the heliogravures issued a few years ago by the late Prof. E. T. Harper may be cited (1913, 1914*a*, *b*, 1916).

Let us now take a glance at the principal fungus-works of the past three hundred years. The very early herbalists paid little attention to the fungi, merely repeating what we find in the

[4] The blue and yellow colors, being complementaries, make a gray-green rather than a pure green.

ancient Greek and Roman writers, Theophrastus, Nikander, Pliny, Galen, and the rest. When there are figures, they are almost without exception extremely poor and almost useless. The earliest published illustrations of fungi that serve us today with any degree of satisfaction in the matter of generic and, in many cases, of specific determination are unquestionably those of Charles de l'Ecluse (Carolus Clusius) published by him in 1601 in his work on Hungarian fungi (1601). They are uncolored wood-cuts, rather clumsily done, but, for all that, sufficiently well characterized where common well-known species are shown. Much better and more serviceable in taxonomic work are the original water-color paintings from which the wood-cuts were made. These water-color pictures, done by an unknown artist working under the direction of Clusius' Hungarian friend and patron, Boldizsar de Batthyany, were published for the first time in colored, lithographic reproduction by Batthyany's countryman, Dr. Gyula de Istvanffi (1900*b*), just 320 years after they were painted, a circumstance which encourages me to believe that my own plates, now reposing in the Farlow collection, may yet see the light of day.

The Istvanffi volume embraces 89 plates—not 91, as the title-page declares. One of Dr. H. A. Kelly's[5] book-dealers in Europe wrote to Istvanffi to have him explain the discrepancy. Istvanffi replied that it was due to a typographical error which he could not correct.

The colored plates are so good that Istvanffi recognizes 112 of the 117 figures represented; and Reichardt (1876*c*) distinguished 47 genera and 102 species. Especially noteworthy are the figures of *Morchella esculenta* (Pl. 1), *Russula foetens* (Pl. 8), *Russula nigricans* (Pl. 13), *Russula virescens* (Pl. 40), *Amanita muscaria* (Pl. 28), *Amanitopsis plumbea* (Pl. 31), *Lepiota procera* (Pl. 58. Reproduced here, in black-and-white, in Pl. 27), and *Polyporus squamosus* (Pl. 19). One figure, that of *Russula foetens,* is so well done that the upper surface of the pileus distinctly shows where a slug ate through the substance

[5] *Editor's Note.*—Mr. Krieger is associated with Dr. Howard A. Kelly, of Baltimore, in mycological and scientific artistic work.

down to the level of the gill-attachments. Altogether, the figures are painted with a freshness of observation that indicates no mean ability on the part of the artist who painted them.

With the exception of Dr. Seger's aforementioned, copper-engraved figures of the anthropomorphic *Geaster* and the queer *Xylaria,* nothing of consequence appeared until Franciscus van Sterbeeck published his "Theatrum Fungorum" (1675).

For the most part this book is a mere curiosity. Its copper-engraved, uncolored figures are copies after Clusius, Seger, and others; indeed, both the *Anthropomorphus* and the *Xylaria* of Seger appear in re-engraved plates. A few are based on water-color drawings of his own finds. I wish to call attention to one of these, his figure of "*Locellus,*" on Pl. 15, at the letter "*C*" (Pl. 28, *A* in this paper). Much has been written on this figure by Kickx (1842*b*), and by Van Bambeke (1905*a,* 1908). The latter is inclined to regard it as a representation of the lower part of the stem of *Morchella crassipes.* A rather long, lacunosely-furrowed object of ovoid shape is shown. To me it suggests Peck's genus *Underwoodia,* a most remarkable discomycete of which E. T. Harper gave some good photographs in the *Bulletin of the Torrey Botanical Club* (1918*b*. See my Pl. 28, *B*).

In order to establish whether the two are identical or not, one would have to examine Sterbeeck's specimen for the presence of the hymenial layer, but, as the specimen has been long since lost, a further discussion is futile and unprofitable. Léveillé (1855), in his re-issue of Paulet, figures the plant in color, and calls it *Clathrus locellus,* a name that seems to have escaped the indexers. Antedating Van Bambeke, he, too, refers it to *Morchella,* but to *Morchella esculenta.* Other attempts to identify Sterbeeck's figures are those of Istvanffi (1894*b, c,* 1895*b, c*) and Britzelmayr (1894*a*). The poor quality of these engravings is to be wondered at as good workmen on copper were becoming plentiful about this time, the latter part of the seventeenth century. The reproduction of Rubens' pictures had called forth a swarm of them; Rembrandt, the master-etcher, must have exerted some influence on those about him; and Swammerdam was at work upon his marvellous drawings of the internal anatomy of the may-fly, published later by Boerhaave (1737*a*).

In the eighteenth century things began to brighten. The evil effects of the Thirty-Years War of the previous century were disappearing; the coffers of the kings and of the merchants were again filling with gold; the men of science thrived. Vaillant certainly looks prosperous enough in the portrait-engraving that forms the frontispiece of his "Botanicon Parisiense" (1727). But few fungi are figured in this work. *Peziza acetabulum* is well done, and so, perhaps, is *Cantharellus cibarius*. The figure of *Amanita phalloides*, on Pl. 14, recalls the fact that Vaillant is the author of the first fairly clear description of this deadliest of all agarics. The engravings, which were done by Claude Aubriet, are uncolored and very fine in execution; yes, too fine, for they show a finish that manicures and bedizens nature into a kind of studied artificiality which must have pleased the artificial people of his time.

Two years later (1729) appeared the work of the great Italian, Pier' Antonio Micheli, who was the first to point out definitely that fungi have reproductive bodies or spores. With the exception of Robert Hooke's drawing of the teleutospore of a *Phragmidium* (1665) and Marsigli's demonstration (1714) of the origin of fungi from mycelia, there is little in the literature before Micheli to indicate that fungi were anything more than freaks of nature produced by spontaneous generation or by thunderbolts, spooks, and the like. Micheli's epoch-making "Nova Plantarum Genera" (1729) changed the views of mycologists forever. Prof. A. H. R. Buller, of the University of Manitoba, pays a glowing tribute to this investigator in a paper entitled, "Micheli and the Discovery of Reproduction in Fungi" (1915). In some plates, carefully copied by Prof. Buller from the originals, are shown gills, tubes, cystidia, basidia, and spores, of agarics and boleti. The gill-fungi, described and illustrated by Micheli, have been critically reviewed by his countryman, Martelli (1884*b*), in the Nuovo Giornale Botanico Italiano.

Before proceeding, I would also call your attention to a curious drawing in Marsigli's work, the "Generatione Fungorum" (1714). One of the plates represents some agarics—apparently a species of *Coprinus*—growing from water in a flask, the neck

of which is corked up, in truly modern, pure-culture style, with a plug of some fibrous material (Pl. 29). It was not until 167 years later that a similar observation was made, by Dr. Farlow. In 1881, this eminent mycologist published an interesting account of the growth of a *Coprinus* on the surface of water contained in a glass jar that had stood for two months in his laboratory (1881*c*). To my knowledge, these two cases are the only ones on record where Basidiomycetes were found growing in or on water.

But, to continue. Micheli's "Nova Plantarum Genera" was followed by Battarra's "Fungorum Agri Ariminensis Historia" (1755), a work that fell short of the standard set by Micheli. To quote Persoon (1818), "In Battarra's time, the science of mycology had not yet acquired the impetus it exhibited later," that is, during his own time, at the end of the eighteenth and the early part of the nineteenth centuries. In Germany, during the years 1762 to 1774, Jacob Christian Schaeffer was issuing that milestone of illustrative mycology, his "Fungi of Bavaria and the Palatinate" (1762). The plates (hand-colored copper-engravings) are not particularly good, but important as one of the original sources for the figures of many well-known species. Persoon, in 1800 (l. c.), re-issued the work without change.

1761 saw the beginning of the extensive "Flora Danica" (1761) in which Vahl, Müller, and others described and figured new species. This work, and the "Flora of the Netherlands" (the "Flora Batava," 1800*a*), are performances, by small countries, which few larger ones have imitated.

In 1788 appeared James Bolton's "An History of Fungusses growing about Halifax" (1788), a work with wretched, hand-colored engravings, but with much historical significance, as is proven by the appearance, only last year, of Sartory and Maire's interesting and learned paper on the "Interpretation of Bolton's Plates" (1920*b*).

A veritable flood of illustrated mycological works was let loose from then on. In France, from 1786 to 1798, we have Pierre Bulliard's colossal "Herbier de la France" (1780), with 602 admirably executed, color-printed (!) engravings; and Paulet's

"Traité des Champignons" (1793*b*), with very inferior plates. Sowerby, in England, was publishing, from 1795 to 1815, the "Couloured Figures of English Fungi" (1795), which, with Greville's later "Scottish Cryptogamic Flora" (1823), represents the best that Britain has produced in the line of fungous illustrations—Cooke's "Illustrations" (1881*b*) notwithstanding.[6]

It must be noted here that Bulliard's set often lacks plates 601 and 602. These were re-issued by Raspail (1840); and Letellier (1829*b*) began a continuation of the "Herbier" by publishing, without text, a series of plates numbered from 603 to 710. Letellier's series is extremely rare, and the illustrations are inferior to those of Bulliard. Still worse is a series of 425 plates by Captain Lucand, 1881 to 1896, also intended as a continuation of Bulliard (1881*d*).

Paulet's "Traité" (1793*b*) is almost never to be had with its plates. Léveillé, in 1855, therefore, re-issued the 207 numbers, with no improvement in quality (1855).

With the dawn of the nineteenth century—in 1801—systematic mycology had its real beginning. All mycologists will recall that, in 1900, certain gentlemen of a conservative turn of mind assembled in the city of Brussels to fix a starting-point for the nomenclature of the fungi. After hearing the report of a committee (1910*a, c, d*), it was decided to take as a starting-point Elias Fries' Systema Mycologicum (1821). Two years before, at the 1908 meeting of the Botanical Society of America held in Baltimore, one voice, that of Prof. Elias J. Durand (1909*a, b*), was raised in favor of Christian Heinrich Persoon's "Synopsis Methodica Fungorum" (1801). Working in an attic in a poor quarter of Paris, this genius with infinite labor sifted the literature of the ages and, for the first time, brought order out of chaos. One hundred and nine years later, a Botanical Congress refused to recognize his great work. It is to be hoped that there will yet be a *real* International Botanical Congress which will deal with this subject with more reason and justice.

[6] Mr. Carlton Rea's "Monograph of the British Basidiomyceteae," the publication of which has just been announced, will undoubtedly add further luster to British illustrative mycology.

Persoon's "Synopsis" does not contain any colored illustrations, nor are there many plates in his two "Icones" (1798, 1803), but such as we find display fine taste and careful workmanship.

Of about the same quality are the illustrations which ornament the work of the Rev. Lewis David de Schweinitz, the first American mycologist. Born in Bethlehem, Pa., this minister in the Moravian church issued, in 1822, his "Synopsis" of North Carolina fungi (1822), with two hand-colored copper plates. Previously, while studying in Germany, he had published, together with his master, de Albertini, a work on the fungi of a district in Germany called "the Lausitz" (1805). Twelve colored plates, done by himself, accompany this publication. Before the time of de Schweinitz, little had been printed on the fungi of our country. The Rev. Mühlenberg's catalogues of Lancaster (Pa.) plants (1793*a*, 1799) contain mere lists, and Gronovius' "Flora Virginica," published in 1739 and 1743 (1739), notes a few collections by Dr. John Clayton, among them, *Lycoperdon solidum*, the "Tuckahoe" of the American Indians.

De Schweinitz's life and scientific labors have been recently treated with loving care and painstaking thoroughness by Drs. Shear & Stevens (1917). But, whereas de Schweinitz's auspicious beginnings in the mycology of this country bore no immediate fruits comparable with his own work, Europe, by contrast, was putting forth some important publications, many of them classics.

Italy gives us Giovanni Larber, whose work of 21 hand-colored plates (1829*a*) I have not seen; Domenico Viviani's "Fungi d'Italia" (1834), with 60 hand-colored lithographs of passable quality; and (1835) Carlo Vittadini's masterpiece, the "Descrizione dei Funghi Mangerecci." This work of 44 colored, engraved plates shows, by its incisive seriousness, kinship with the performance of Micheli, Vittadini's great predecessor.

Across the line, in Austria, things were stirring, too. About this time, Krombholz's 76 hand-colored "Naturgetreue Abbildungen der Schwämme" (1831) appeared in parts from 1831 to 1847. The figures in this rather comprehensive book are tolerably well drawn, but much too crowded on the page, and the colors

are merely dashed on. It is a bad practice to crowd figures on the page. Reference becomes difficult, and the individuality of the plants represented is lost in the general jumble.

The fourth decade of the new century offers, first, a work which I have not seen, Harzer's 80 plates, issued during the years 1842 to 1845 (1842*a*). Then, from England, in 1847, we get Badham's exceedingly well written, but poorly illustrated, "Treatise on the Esculent Funguses" (1847*a*), a later edition of which appeared in 1864, edited by Frederick Currey (l. c.). The first edition of the "Treatise" has 21 colored plates; the second, only 12. England, during this period, had also a woman mycologist, Mrs. T. J. Hussey, who presented to the world one of the most charming mushroom books known, her "Illustrations of British Mycology" (1847*b*), published in two series of hand-colored lithographs, 140 plates in all. The second series, comprising the last fifty plates, is very scarce.

As we approach the second half of the nineteenth century, the representation of the mere outward appearance of the fungi no longer satisfied—the internal, microscopic structures, the life histories, the phylogenetic, parasitic, and symbiotic relationships, were engaging the attention of mycologists. Such men as the Tulasne brothers, de Bary, Brefeld, de Seynes, and a host of others, arose. In great detail, and with surpassing skill, the Tulasnes studied and illustrated the external and the internal structures of the Hypogaei (1851), the lichens (1852), the Tremellineae (1853), and the gastromycetous groups and genera, Nidulariaceae (1844), *Lycoperdon, Bovista, Scleroderma, Polysaccum,* and *Geaster* (1842*c, d,* 1843*a, b*), and the Ascomycetes (1861*b*). I think it is safe to say that *never again will such hand-work appear as we find reproduced in the stupendous monographs issued by these two unassuming brothers. Commercialism has killed the possibility; men are no longer training their minds, eyes, and hands for such work—the art is dead!*

Along with these important investigational works, atlases of the greatest moment kept on appearing. For want of time, I can do little more than enumerate the best. First, and foremost, Elias Fries' "Icones" with 200 colored plates (1867), preceded

by his more popular "Sveriges Ätliga och Giftiga Svampar" with 93 colored plates (1861*a*); Gillet's "Champignons de France" (1874) with nearly 900 hand-colored lithographic drawings, which, because of the three systems of numbering, are difficult to consult (1876*a*, 1898); Kalchbrenner's 40 plates of Hungarian species (1873*b*, 1876*b*, 1884*a*); the Rev. Bresadola's "Fungi Tridentini" of 217 colored lithos. (1881*a*); the same author's "Funghi Mangerecci e Velenosi dell' Europa Media" (1899*a*); Cooke's "Mycographia" (1875), his 1199 "Illustrations of British Fungi" (1881*b*), and his "Australian Fungi" (1892), all of which have become more useful through commentaries (1899*c*, 1907); Quélet's "Champignons du Jura et des Vosges" (1872) with its many supplements and 66 (?) plates; Barla's "Champignons de Nice" (1859), followed by his "Flore Mycologique des Alpes Maritimes" (1888), together holding 112 colored plates; finally Lanzi's "Edible and Poisonous Fungi of Rome" (1894*d*), 131 hand-colored lithographs of only fair quality; and, Saunders and Smith's 48 colored plates (1871), part second of which was critically reviewed by the illustrious Fries (1873*a*).

Also there was an interminable number of lesser works: Berkeley's "Outlines" (1860), which has been called "a publisher's book"; Valenti-Serini's caricatures (he figures stems of Amanitas that look like designs for some new style of architectural column (1868*b*)); Leuba's figures on black backgrounds (1887); Richon and Roze's moderately good "Atlas" (1885); and Maximilian Britzelmayr's "Hymenomyceten aus Süd-Bayern" (1879, 1895*a*), a work that Lloyd has justly pronounced, "the poorest excuse for an illustrated work on fungi" (1914*c*). The drawings are mere bedaubed, mimeographed, or zinc-plate figures, on plates of unequal size, and in absolute disorder. Fortunately, Dr. von Höhnel has furnished the suffering systematist with an index to this chaotic mass (1906*a*).

Hollos' "Gastromyceten Ungarns" (1904) opens our century. If you wish to see what a sorry show the tri-color product—at its worst—presents when compared with really excellent lithographic reproductions, look at Hollos' book, and then turn to Boudier! The 600 magnificent, colored plates of Boudier's

"Icones" (1905*b*) run a close second to the Tulasne *chefs-d'oeuvre*. It is a positive delight to use them; indeed, were all published plates like these, there would be little question as to the identity of species. In nearly every case he gives the plant in different stages of development; the sectional views are always included, as are also the microscopic details (Pl. 30). Only 125 copies were printed, of which 115 were sold to the original subscribers. Eight copies were subscribed for in the United States. The subscription price for the entire work of three atlas volumes and one of text was $210.00. Today, the price is rapidly approaching $500.00.

Since the appearance of Boudier's masterpiece one other color-illustrated work of scientific importance has been published, namely, Rev. Adalbert Ricken's "Die Blätterpilze Deutschlands" (1910*e*). Boudier and Ricken are illustrations of the statement I made earlier, that the lithographic process, though producing the most durable results, has to contend with two variable factors, the artist and the lithographer. Given a good artist and a good lithographer, you get such work as Boudier's; with poor workmen, both on the paper and on the stone, you get Ricken's well-meant, but puerile, illustrations.

In conclusion, I would like to point out how little has been done in this country in the matter of publishing colored illustrations of our rich fungous flora.

First, we have de Schweinitz's early work (1822), already mentioned, with exactly two plates. Following him came the Rev. M. A. Curtis, who was urged by Asa Gray (1868*a*) to prepare a manual of the fungi of the United States. Nothing came of this. But, that Curtis seriously entertained the idea of publishing some comprehensive, illustrated manual of these plants, appears from statements made by E. R. Memminger (1905*c*) to the effect that Curtis actually left a fragmentary manuscript with illustrations. This is still in the possession of his children.

Indeed, the only atlas of colored illustrations of the commoner species of our fleshy fungi is the one published by the late Prof. Charles Horton Peck (1895*d*), who, for upwards of forty years, was the State Botanist of New York. Professor Peck's illustra-

tions, botanically accurate though they be, are not much more than colored diagrams, with little of the appearance of nature about them. Other illustrations by this most eminent student of our species are scattered through the reports of the New York State Museum. A few plates have also been published by Professor Murrill, of the New York Botanical Garden (1909*c*), and by Miss Burlingham (1921), all in the journal MYCOLOGIA.

McIlvaine's sketches in his "One Thousand American Fungi" (1900*c*) fall far short of even a half-respectable standard; and the few colored plates in Professor Atkinson's book (1900*a*) are so bad that they were omitted from the later editions.

Dr. Harkness' four colored plates in his paper on the Californian hypogaeous fungi (1899*b*) must not be omitted, as well as my own plates, published last year in the *National Geographic Magazine* (1920*a*, and Pl. 31 in this paper).

This short enumeration about completes the list of American colored figures of fungi to be found in our publications. Compared with the output of Europe,[7] it is negligible. But there is a ray of hope; Dr. Kelly has asked me to revise, and supply with colored illustrations, Prof. Peck's monograph of the genus Boletus (1889), the revision to stand as a memorial of this great American botanist. I trust that it may be printed.

BALTIMORE, MD.

EXPLANATION OF PLATES

Pl. 24. Dr. Seger's "Anthropomorphus," described in 1671.

Pl. 25. "The Cannon." Etching on iron by Albrecht Dürer.

Pl. 26. (*A*) Photographic enlargement (about 7 diameters) of the heliogravure reproduction shown in the upper left corner (*a*). A hand-lens examination of a heliographic reproduction of a photograph is thus instructive to the systematic mycologist, it being possible to determine whether the dimidiate gills are attached to their longer neighbors, or not. The opposite is true of the reproduction (*B*) of the half-tone figure (*b*).

Pl. 27. *Lepiota procera* (Scop.) Pers. Photographic reproduction from the colored lithographic figure in Istvanffi's Études et commentaires sur le code de l'Escluse, pl. 58. The original of this figure was painted during the latter part of the sixteenth century, about 1580. See plate 31.

Pl. 28. (*A*) "Locellus," in Sterbeeck's "Theatrum Fungorum," pl. 15, at "*C*." (*B*) *Underwoodia columnaris* Peck. After E. T. Harper.

[7] See Laplanche (1894*e*) and Traverso (1910*f*) for two indexes of the available, published illustrations of fungi.

Pl. 29. Agarics (*Coprinus* species?) growing in a flask. After Marsigli's "Generatione fungorum."

Pl. 30. *Lepiota rhacodes* (Vittad.) Fr. Photographic reproduction of plate in Boudier's "Icones."

Pl. 31. *Lepiota procera* (Scop.) Pers. Photographic reproduction of a water-color painting by the author. The original in the possession of Dr. Howard A. Kelly. Reproduced in colors in the National Geographic Magazine, May, 1920. See plate 27.

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b **Burch, R. M.** Colour printing and colour printers. London. *Plates (mostly col.).*

c **Farlow, W. G., & Atkinson, G. F.** The botanical congress at Brussels. Science n. s., **32:** 104–107. Jl. 22.

—— —— Bot. Gaz. **50:** 220–225. Sep. 21.

d **Lloyd, C. G.** Our latest laws "by authority." In his Mycological Notes no. 36: 478–479.

e **Ricken, Adalbert.** Die Blätterpilze (Agaricaceae) Deutschlands und der angrenzenden Länder. Leipzig, 1910–15. 2 v. *112 col. pl.*

f **Traverso, G. B.** Index iconum fungorum. In Saccardo, P. A., Sylloge fungorum hucusque cognitorum v. 19–20. Patavii, 1910–11.

1913 **Harper, E. T.** Species of Pholiota of the region of the Great Lakes. Trans. Wisc. Acad. Sci. **17** (pt. 1): 470–502. *Pl. xxiv–lv.*

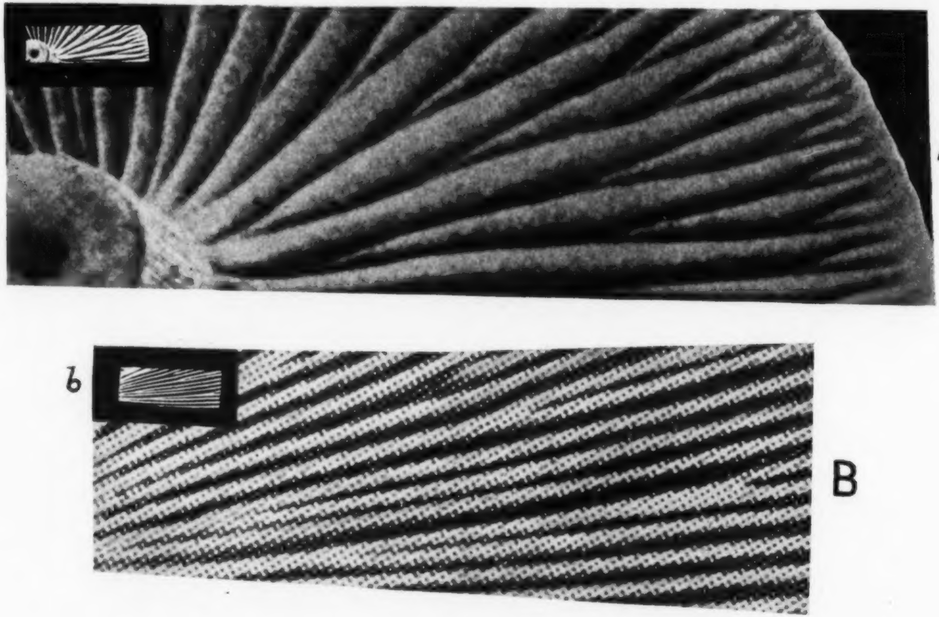
1914 *a* **Harper, E. T.** Species of Pholiota and Stropharia in the region of the Great Lakes. Trans. Wisc. Acad. Sci. **17** (pt. 2): 1011–1026. *Pl. lix–lxvii.*

DR. SEGER'S "ANTHROPOMORPHUS"

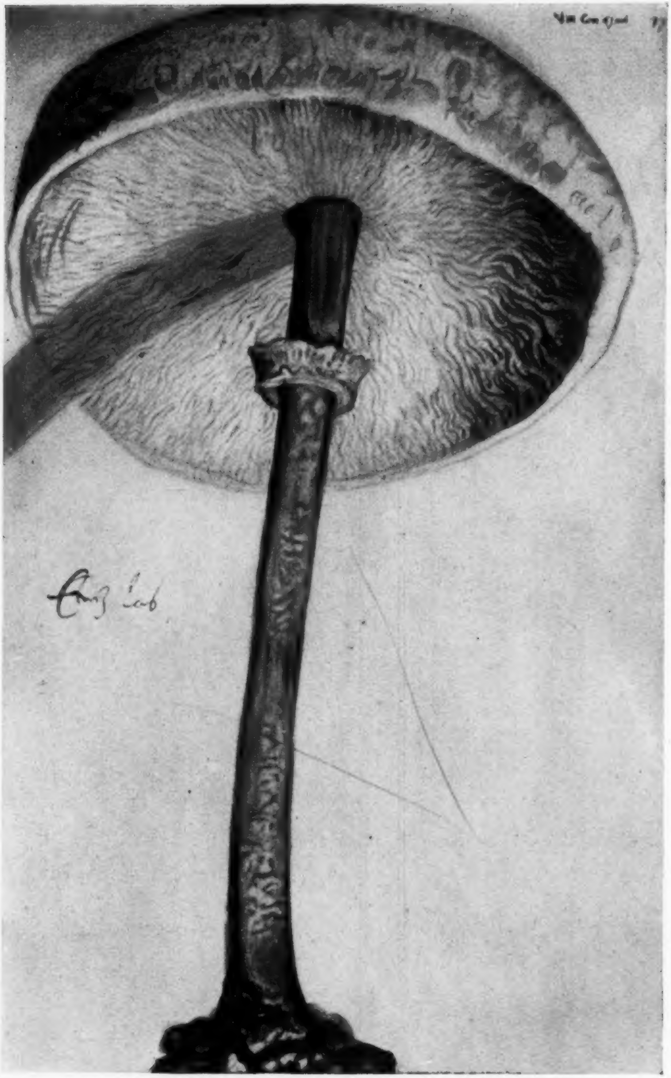
"The Cannon," by Dürer

a A

b B

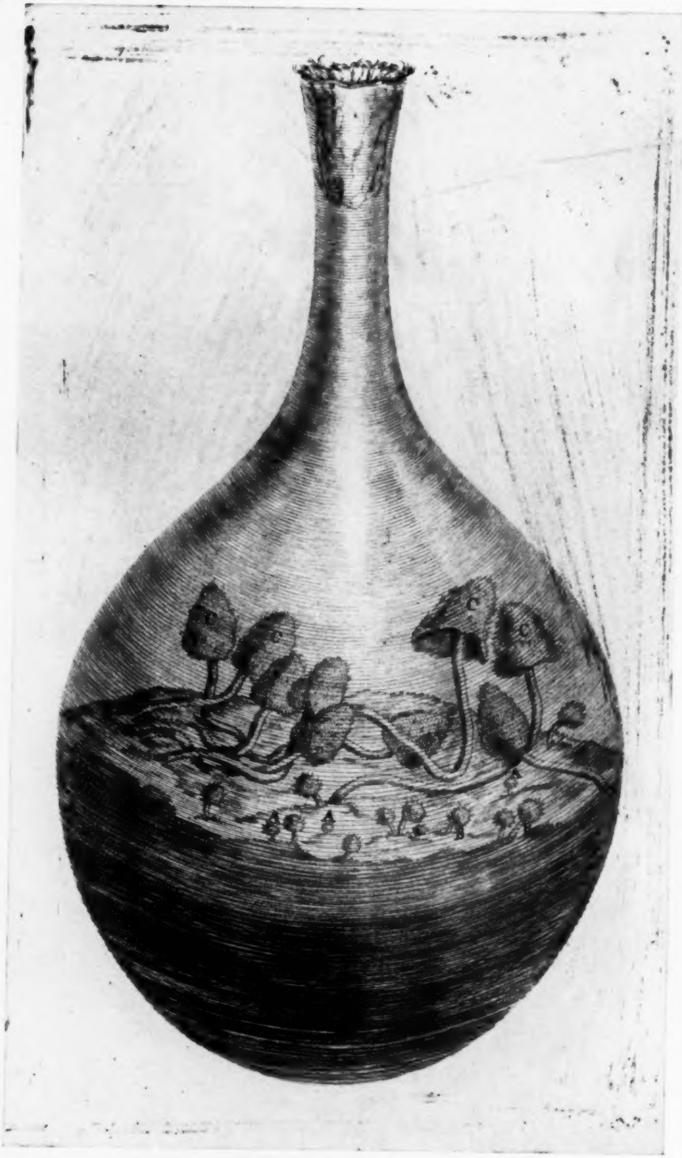


Photographic Enlargements of Heliogravure Reproductions



LEPIOTA PROCERA (SCOP.) PERS. FROM ISTVANFFI'S "ÉTUDES"

A. "Locellus," from Sterbeeck's "Theatrum"
B. Underwoodia columnaris Peck. After E. T. Harper



AGARICS (COPRINUS?). AFTER MARSIGLI

LEPIOTA RHACODES (VITTAD.) FR. FROM BOUDIER'S "ICONES"

LEPIOTA PROCERA (SCOP.) PERS. FROM NAT. GEOGR. MAG.

b —— Species of Hypholoma in the region of the Great Lakes. Trans. Wisc. Acad. Sci. **17** (pt. 2): 1142–1164. *Pl. lxxii–lxxxiv.*

c **Lloyd, C. G.** [Britzelmayr, Hymenomyceten aus Südbayern.] Bibl. Contr. Lloyd Library 2: 248.

1915 **Buller, A. H. R.** Micheli and the discovery of reproduction in fungi. Trans. Roy. Soc. Canada III. **9** (pt. 4): 1–25. *Pl. 1–4.*

1916 **Harper, E. T.** Additional species of Pholiota, Stropharia, and Hypholoma in the region of the Great Lakes. Trans. Wisc. Acad. Sci. **18** (pt. 2): 392–421. *Pl. xi–xxiv.*

1917 **Shear, C. L., & Stevens, N. E.** Studies of the Schweinitz collections of fungi. I–II. Mycologia **9**: 191–204, 333–344.

1918 *a* **Bensaude, Mathilde.** Recherches sur le cycle evolutif et la sexualité chez les Basidiomycètes. Nemours. *30 figs., 13 pl.*

b **Harper, E. T.** Two remarkable Discomycetes. Bull. Torrey Bot. Club **45**: 77–86. *Pl. 1–3.*

1920 *a* **Krieger, L. C. C.** Common mushrooms of the United States. Nat. Geogr. Mag. **37**: 387–439. *16 col. pl. and many photos.*

b **Sartory, Auguste, & Maire, Louis.** Interpretation des planches de J. Bolton on History of fungusses. Vol. I et II (1788). Saint-Nicolas-du-Port.

1921 **Burlingham, G. S.** Some new species of Russula. Mycologia **13**: 129–134. *Pl. 7.*

INDEX TO ILLUSTRATIONS OF FUNGI, XXIII–XXXIII

William A. Murrill

In Mycologia for January, 1916, an index was published to species illustrated in the first 22 articles of my series on the higher fungi, which was begun in the first volume of Mycologia in 1909. Since that time, 11 more articles have appeared, which are indexed below. The total number of species described and illustrated to date is 249, the number represented in their natural colors being 213 on 29 plates.

Unfortunately, it has been necessary to crowd the figures on the plates, but most of them have been kept natural size and represent fairly well the species illustrated.

The idea of a great illustrated work on American fungi has been in my mind for many years and I have frequently spoken and written about it. Several hundred colored drawings have been prepared with such a work in view. When the raising of funds for this purpose became increasingly difficult, I decided to publish in a comparatively inexpensive way as many species as possible as quickly as possible; so that collectors might be stimulated to increase our knowledge of the fungous flora and thus prepare for a more comprehensive work when its publication should become possible. From the large number of letters and specimens received during recent years, I am convinced that it was wise to publish when I did. As one writer expressed it: "I'd much rather have a small colored figure now than a handsome folio plate after I am dead."

I still have faith, however, in the patriotism and generosity of American men of wealth, who will make it possible to supply nature-lovers in this country with ample, correct, and beautiful colored illustrations of our extremely varied and interesting fungous flora.

NEW YORK BOTANICAL GARDEN.

NOTES AND BRIEF ARTICLES

[Unsigned notes are by the editor]

The familiar stem-end rot of pineapples can be largely controlled, according to J. Matz, of the Porto Rico Department of Agriculture, by leaving longer stems on the fruit and fumigating with formaldehyde gas.

Sphaeropsis ulmicola is thought to be the cause of a serious canker of the branches of the American elm in Wisconsin. Most of the trees affected are fifteen years or more old. See Wisconsin Dept. Agric. Bull. **33**: 158–163, by E. E. Hubert & C. J. Humphrey.

Mr. H. E. Parks has sent to the herbarium a number of interesting, original photographs of California fungi, including good views of *Rhizopogon maculatus, Hydnangium carneum,* and *Secotium tenuipes.*

Plant diseases, especially in greenhouses, have been traced in many instances to the water supply. W. F. Bewley and W. Buddin have cited a number of cases in a recent article in the *Annals of Applied Biology.*

A wither-tip of limes, caused by *Gloeosporium limetticola,* is said to be common on lime trees in British Guiana during July and August, when frequent applications of strong Bordeaux mixture are required to hold the disease in check. Fortunately, the fruits are usually immune after they are half grown.

Leaf-spot of orchids is not a single, specific disease, but a complication of various troubles needing careful and intensive investigation. This is the conclusion of a number of plant pathologists, including W. B. Brierley, of the new Rothamsted Experiment Station in England.

The needle-blight of white pine is said by J. H. Faull, who has observed and investigated it for several years, to be physiological in its nature. Warm, bright days in winter, when the ground is frozen and the roots inactive, cause excessive loss of water from the tips of the leaves and they dry out and become brown.

A paper by E. B. Mains on unusual rusts of *Nyssa* and *Urticastrum,* published in the *American Journal of Botany* for November, 1921, includes a description of the new genus *Aplospora,* based on *Uredo Nyssae,* and two new combinations, *Aplospora Nyssae* (Ellis & Tracy) Mains and *Cerotetium Dicentrae* (Trel.) Mains & Anderson.

Greenhouse diseases observed at Macdonald College, Quebec, were briefly noted by B. T. Dickson in a recent annual report of the Quebec Society for the Protection of Plants. The chief diseases discussed are: carnation rust; cineraria dwarfing, mosaic, and distortion; snapdragon rust; sweet pea powdery mildew; tomato mosaic and a leaf-mold; and violet leaf-spot.

A bud-rot of peonies, which has been observed by various persons during the past few years, was described by H. W. Thurston, Jr. & C. R. Orton in *Science* for 1921. Just as the flower buds are swelling, they turn black and decay, the disease often extending to the upper leaves and several inches of the stalk. Infected material yielded a species of *Phytophthora* closely related to *P. infestans.*

A bacterial disease of gladiolus, caused by *Bacterium marginatum,* was described by L. McCulloch in *Science* for 1921. It is abundant in and about Washington, D. C., and probably occurs also in Illinois and California. The affected leaves show elliptic spots that are at first rusty-red, then dull-brown or purplish. Moist, warm weather is very favorable to the growth of the pathogen, often resulting in the decay of the entire plant above ground.

The following new parasitic fungi were described and illustrated by J. J. Davis in the *Transactions of the Wisconsin Academy of Sciences* **20:** 399–431. 1922: *Synchytrium pulvereum, Septoria coreopsidis, Gloeosporium balsameae, Ramularia minax, R. cilinodis, Sphaerulina pallens, Phacidium planum, P. expansum, P. balsameae, Lophodermium thuyae, Stagonospora tetramera, Piggotia vaccinii, Gloeosporium bicolor, Cladosporium astericola, Cercospora tuberculella,* and *C. tortipes.*

In an article by Miss Wakefield in the *West Indian Bulletin* for 1921, the general subject of mosaic diseases of plants and their origin is discussed at some length. Infection by a living organism seems to be the only way to cause mosaic, according to Miss Wakefield; while "discovery of a possible symplastic stage in bacteria, and of the formation of filterable gonidia which may produce new bacteria directly or after having entered the symplastic stage, appears to increase the possibility that eventually many of the infectious filterable viruses may prove to contain living organims."

The treatment of seeds before planting has usually been based on the supposition that the pathogen to be controlled was external; but C. C. Chen, of the Maryland Experiment Station, has discovered a number of internal fungous parasites of agricultural seeds. For example, *Cylindrophora* in asparagus seed; *Alternaria* in cabbage seed; *Fusarium, Macrosporium,* and *Alternaria* in common beans; *Fusarium* in lima beans; *Macrosporium* in cowpeas; *Macrosporium* and *Fusarium* in soy beans; *Oospora* in sweet corn seedlings; and *Rhizopus* in seeds taken from a rotten tomato. He recommends seed selection, the germination test, and the most approved hot water and hot air treatments.

Forty-two numbers of fungi were brought back from South America by Dr. H. H. Rusby, collected by himself and other members of the Mulford biological exploring party in Bolivia. Whenever possible, sufficient material was obtained to make four sets, three of them to be deposited at the New York Botanical Garden,

the Brooklyn Botanic Garden, and Harvard University, and the remaining one to be sent to Bolivia. These specimens are mostly woody polypores or tough gill-fungi. Attention may be called to the very rare *Camillea Leprieurii* Mont. and to the following species of less interest: *Armillaria alphitophylla* (Berk. & Curt.) Murrill, *Lentodiellum concavum* (Berk.) Murrill, *Lentinula detonsa* (Fries) Murrill, *Cookeina Tricholoma* (Mont.) O. Kuntze, and *Cladoderris dendritica* Pers.

INDEX TO VOLUME XIV*

New names and the final members of new combinations are in **bold face type**

* It has been considered unnecessary to include here the species listed in the three following articles, since they are already indexed or specially listed.

Arthur: Uredinales collected by Fred J. Seaver in Trinidad. See p. 23, 24.

Murrill: Index to illustrations of fungi, XXIII–XXXIII. See p. 332.

Wann and Muenscher: A preliminary list of the myxomycetes of the Cayuga Lake Basin. See p. 39.